Sustainable Natural Rubber-Based Waterborne Polyurethane: Advancing Adhesive and Coating Technologies

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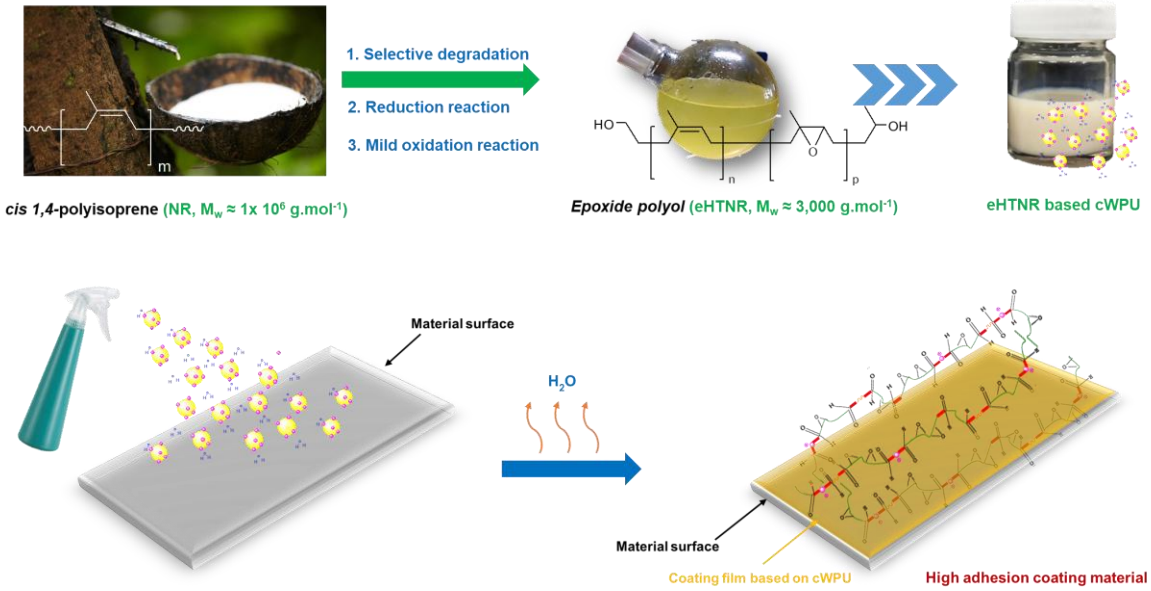
This study reports the synthesis and characterization of sustainable natural rubber (NR)-based cationic waterborne polyurethane (cWPU) adhesives and coatings derived from hydroxyl-terminated natural rubber (HTNR). HTNR with controlled molecular weights (1000–3000 g·mol^{-1}) was synthesized via epoxidation, oxidative cleavage, and reduction, enabling its use as a renewable alternative to petroleum-based polyols. The cWPU dispersions were prepared through step-growth polymerization with a total solid content of approximately 20 wt%. Key formulation parameters—including cationic emulsifier content, chain extender concentration, HTNR molecular weight, NCO index, and epoxide functionality—were systematically investigated. The resulting cWPU latexes exhibited excellent colloidal stability, with particle sizes ranging from 60 to 453 nm and high positive zeta potentials (+50 to +70 mV). Incorporation of ethylene glycol significantly enhanced mechanical strength and reduced solvent swelling. Increasing NCO index and epoxide content induced a transition from elastomeric to more rigid film behavior. Adhesion performance on cow leather substrates demonstrated superior bonding strength compared to commercial adhesives. The optimal formulation, based on HTNR with a molecular weight of ~2000 g·mol^{-1} and 10% epoxide content, exhibited excellent lap shear and peel strength, particularly at a curing temperature of 70 °C. Enhanced adhesion is attributed to the high surface energy and cationic nature of the latex particles, promoting strong interactions with polar and negatively charged surfaces. These findings demonstrate the potential of NR-based cWPU as an eco-friendly, high-performance adhesive and coating for advanced industrial and leather applications.

Scheme I



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Biography (For Plenary, Keynote, and Invited Speakers)

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Assoc. Prof. Dr. Nathapong Sukhawipat is a lecturer in Division of Polymer Engineering and Rubber Industrial Technology, Department of Mechanical Engineering Technology, College of Industrial Technology (CIT), King Mongkut's University of Technology North Bangko. He obtained his Ph.D. in Materials Science and Polymer Science through a joint program between Le Mans Université in France and Prince of Songkla University in Thailand, specializing on natural rubber-based cationic waterborne polyurethane for advanced adhesive applications. His research focuses on natural rubber modification, polyurethane systems, polymer composites, and sustainable materials for adhesives, coatings, and energy applications. He has published widely in high-impact international journals and plays active roles as a Section Editor in Materials Science (Trends in Sciences) and a Guest Editor for international journals. Dr. Sukhawipat has received numerous awards, including the Outstanding Young Researcher Award from KMUTNB and several honors from the National Research Council of Thailand (NRCT) for innovations in sustainable materials and engineering. His work promotes converting renewable and waste-derived resources into high-value polymeric materials, with a focus on eco-friendly rubber-based technologies for industrial use.

Keyword (3-5 keywords use commas to separate each word):
Modification of natural rubber, Polyurethane, Adhesive and coating, Water-based Polyurethane